HANDBOOK OF INSTRUCTIONS

for

MODEL 260A

DC STANDARDS EQUIPMENT

RADIO FREQUENCY LABORATORIES, INC.

BOONTON, NEW JERSEY

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WARNING

OPERATION OF THIS EQUIPMENT INVOLVES THE USE OF HIGH VOLTAGES WHICH ARE DANGEROUS TO LIFE. OPERATING PERSONNEL MUST AT ALL TIMES OBSERVE ALL SAFETY REGULATIONS. DO NOT CHANGE TUBES OR MAKE ADJUSTMENTS INSIDE THE EQUIPMENT WITH VOLTAGE SUPPLY ON. UNDER CERTAIN CONDITIONS DANGEROUS POTENTIALS MAY EXIST IN CIRCUITS WITH POWER CONTROLS IN THE OFF-POSITION DUE TO CHARGES RETAINED BY CAPACITORS, ETC. TO AVOID CASUALTIES ALWAYS DISCHARGE AND GROUND CIRCUITS PRIOR TO TOUCHING THEM.

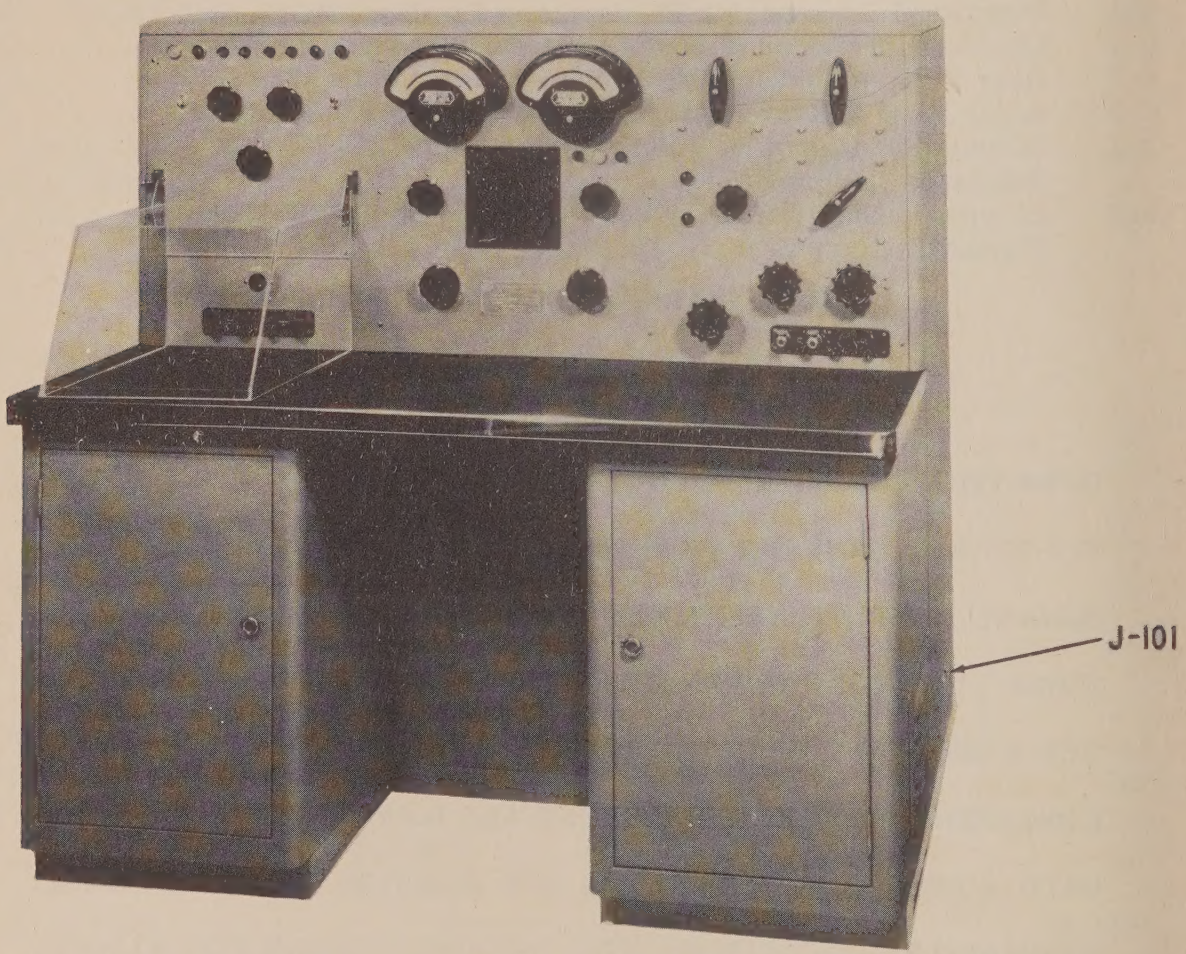


Figure 1-1. Front View of Model 260A DC Standards Equipment

SECTION I
GENERAL DESCRIPTION

1. PURPOSE OF HANDBOOK.

The purpose of this handbook is to provide operating and servicing personnel with the necessary information concerning the installation, operation and maintenance of the Model 260A DC Standards Equipment.

2. PURPOSE OF EQUIPMENT.

The Model 260A DC Standards Equipment is designed to provide an accurate means of calibrating DC voltmeters and ammeters, having various full scale ranges and burdens. Since the voltage and current sections are separate and complete, this equipment may also be used to calibrate electrodynamic wattmeters.

3. GENERAL DESCRIPTION.

a. GENERAL. - The Model 260A DC Standards Equipment consists of wide range DC voltage and current sources, control elements and a means of accurately measuring the magnitude of the DC voltage or current that is being applied to an instrument under calibration, all housed in a suitable steel console. See figure 1-1. Doors with electrical interlocks are provided on the back side for servicing.

The left section of the panel contains the main power switch, test voltage switch, fuses, voltage operational controls for voltage calibration and the voltage range selection switch. Controls for the current section are located on the right side. The center section contains the variable auto-transformer magnitude controls for the voltage and microampere circuits. The center section also contains the standard meters, resistance decades and battery charging controls.

The voltage calibrating section operates from an external AC power source of 105 to 125 volts at frequencies ranging from 50 to 1600 cycles and consumes 350 watts. A storage battery supplies the current section.

This battery is located in the right-hand compartment beneath the counter. A battery charger is incorporated with the equipment.

Provision is made for the use of an external AC line voltage regulator (see Section II, paragraph 3b).

b. PROTECTIVE AND SAFETY FEATURES. - Instruments under test are protected against accidental overload by means of interlocks which disconnect the test supply when range settings are changed without first returning the magnitude variable auto-transformer to zero. After interlocks have been tripped, it is necessary to return the magnitude controls to zero to reconnect the power supply to the instrument.

Resistance in the current circuits prevents excessive overloading of the standard meter or the instrument being tested.

On all voltages above 150 volts, operator protection is provided by means of a removable, transparent hood which covers both the meter under test and the voltage output terminals. Lifting the hood actuates an interlock switch behind the panel, shutting off the test supply above 150 volts.

All entrances to the high voltage compartment are provided with interlock switches which cut off the primary source of power when the doors are open.

Internal heaters are provided to guard against the condensation of moisture in humid climates.

4. OPERATING CHARACTERISTICS.

a. POWER SUPPLIES. - The Model 260A DC Standards Equipment requires a power source of 105 to 125 volts AC, single phase, 50 to 1600 cycles per second and consumes 350 watts. The voltage side of the equipment includes a built-in power supply, while the current side is supplied by a self-contained storage battery of 168 ampere-hour capacity.

b. STANDARD INSTRUMENTS. - The equipment's standard DC current instrument has full scale ranges as given in Section VI, paragraph 1f, and will calibrate other DC current instruments to an accuracy of one half of one per cent within the associated maximum terminal burdens or resistance. Most commercial current instruments are covered by these ranges.

The equipment's standard DC voltage instrument has full scale ranges as shown in Section VI, paragraph 1g, and will calibrate to an accuracy of one half of one per cent within the associated maximum terminal burdens. A large number of commercial voltmeters are covered by these ranges. Terminals are provided to obtain zero to 150 millivolts with a minimum load resistance of two ohms. The source of power is derived from a shunt in series with the positive current binding post. The storage battery BT-101 supplies the current ranges.

SECTION II
INSTALLATION AND ADJUSTMENT

1. UNPACKING THE EQUIPMENT.

Carefully remove the external wood protecting cover, then cut the moisture barriers and remove these, exposing the equipment.

2. PRE-INSTALLATION INSPECTION.

Inspect the entire console for damage in shipment. Tighten loose screws and nuts.

3. INSTALLATION.

a. LOCATION. - The Model 260A DC Standards Equipment should be located in a

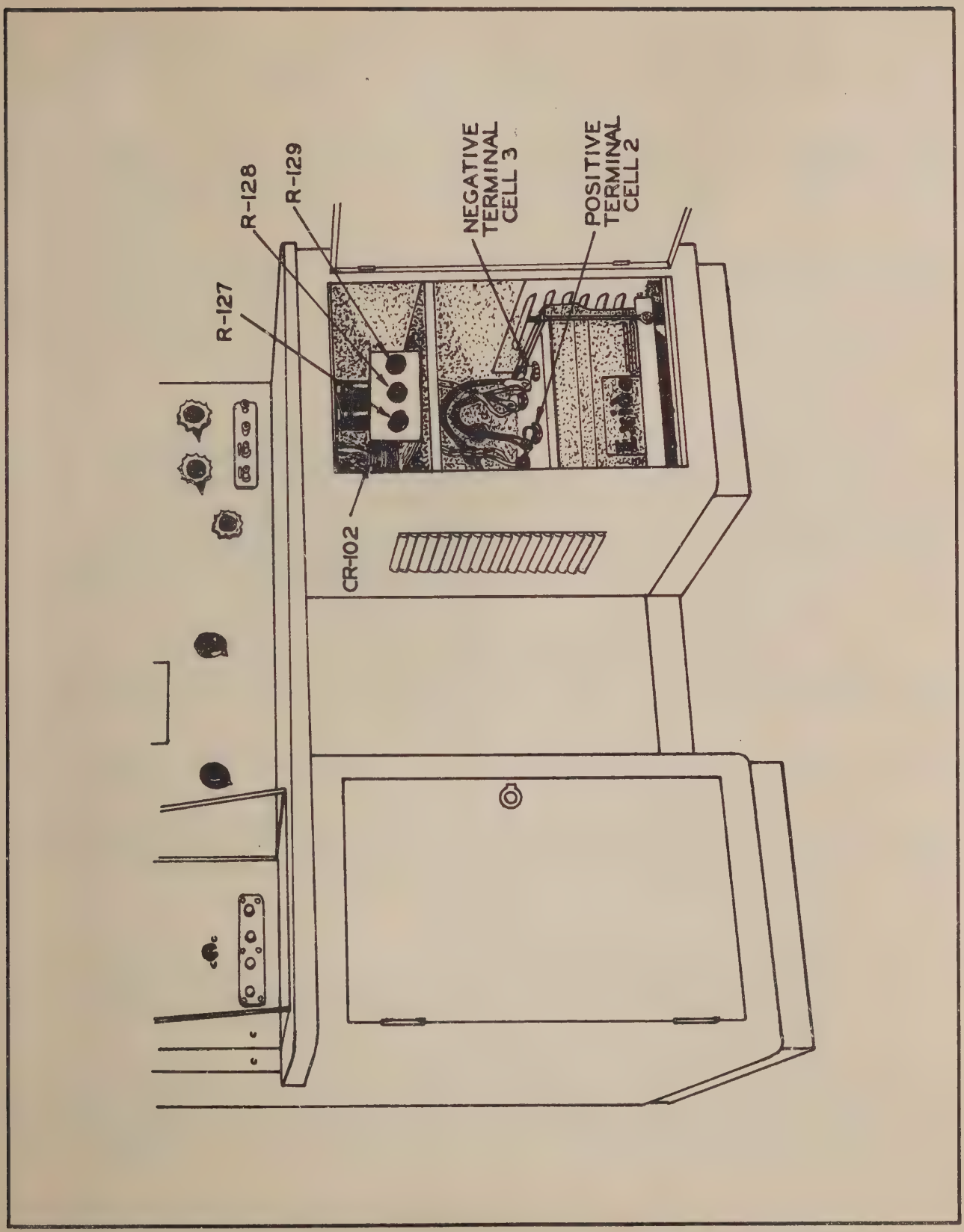


Figure 2-1. View of Battery Compartment

clean room with adequate clearance behind the console to open the rear doors. The console should be left on the shipping skids until moved into place. The skids can be removed by loosening the shipping bolts marked in figure 6-2.

b. CONNECTIONS TO POWER SOURCE AND GROUND. - The AC power is connected through jack J-101. This jack is located on the lower right side of the console, see figure 6-3. The power should always be on the console to supply the internal heaters. The steel case of the equipment must be bonded to a good external ground.

The external power source should be reasonably stable for the length of time required to make instrument readings. An external voltage regulator of proper voltage, frequency and load rating can be connected into the circuit by plugging the input of such a regulator into jack J-102 and connecting the output of the regulator to P-101.

c. BATTERY.

(1) CONTINENTAL SHIPMENT. - For continental shipment the battery is shipped separately and fully charged. Remove the battery carefully from the shipping box. Place the battery in position as shown in figure 2-1 and connect the cables and charging leads as shown in the schematic diagram, figure 8-2. The terminals of the battery and the inside surfaces of the cable connectors should be carefully scraped and cleaned with a knife before connecting. The red tagged leads go to the respective red terminals of the battery. The terminals of the battery and the cable connectors are then coated with vaseline.

The cable connections must be tight. Test the charge of each cell of the battery with a hydrometer before operating. The hydrometer should read between 1280 and 1300 for a fully charged cell.

If the battery is not fully charged refer to Section III, paragraph 7. Put the battery clamps in place and tighten the nuts.

(2) OVERSEAS SHIPMENT. - For overseas shipment, the battery is packed without electrolyte. The electrolyte is shipped in two one gallon bottles. Add the electrolyte to the battery immediately after unpacking the battery.

CAUTION

Do not allow the battery acid to come in contact with hands or clothing. In case of an accident wash acid off immediately with large quantities of water or neutralize with a base. Common baking soda can be used to neutralize the acid.

Install the battery in the equipment as explained in paragraph 3c(1) above and start charging the battery. Seventy-two to ninety hours at full charging rate will bring the battery up to full charge. Set the controls R-127, R-128 and R-129 at 1.18 for maximum rate of charge.

(3) CHARGING AND CARE OF THE BATTERY. - For best results the battery should be kept at full charge. Distilled water is added from time to time to keep the water level above the plates. Do not over-charge.

d. INSTALLATION OF STANDARD INSTRUMENTS. - The standard panel instruments M-101 and M-102 are shipped in a separate case. Remove these instruments very carefully from the case and mount them on the panel in positions as shown in figure 3-1. The necessary nuts, washers and bushings are attached to each instrument. Connect the wires to the back of the instruments as shown in figure 6-3 (studs marked M-101 and M-102).

4. ADJUSTMENT.

Before operation set the mechanical zero of the standard instruments by means of the small screw on the instrument case.

SECTION III
OPERATION

1. GENERAL PRECAUTIONS.

Although many safeguards against destroying the instrument being calibrated have been constructed into this equipment, it is possible that trouble may be encountered due to faulty operation. The following precautions must be taken.

a. Do not block interlocks except as required for period of repair.

b. Keep in mind that the standard instruments are delicate in nature and are designed to give a high degree of accuracy for long periods if treated with care.

c. Turn all magnitude (voltage or current) controls entirely counter-clockwise before turning off source.

d. Do not remove instrument being calibrated while energized. Always return all instrument pointers to zero before continuing.

e. Check all connections and control switch positions before energizing a circuit.

To obtain good accuracy from the Model 260A DC Standards Equipment, two technicians should work together. In the operation the standard instrument is held to value and the instrument to be calibrated is read.

One operator controls the magnitude of voltage or current and, while observing the standard instrument, brings the pointer of the standard instrument near to the designated value, calling "high, high, high", "on, on, on", or "low, low, low" as the case may be. The second operator reads the instrument being calibrated and records its indication.

2. DC VOLTMETER CALIBRATION.

a. PRELIMINARY. - Check to see that the OUTPUT POLARITY switch (S-118 on left side of panel) is OFF, and EXTERNAL RESISTANCE FOR MICROAMPERES is

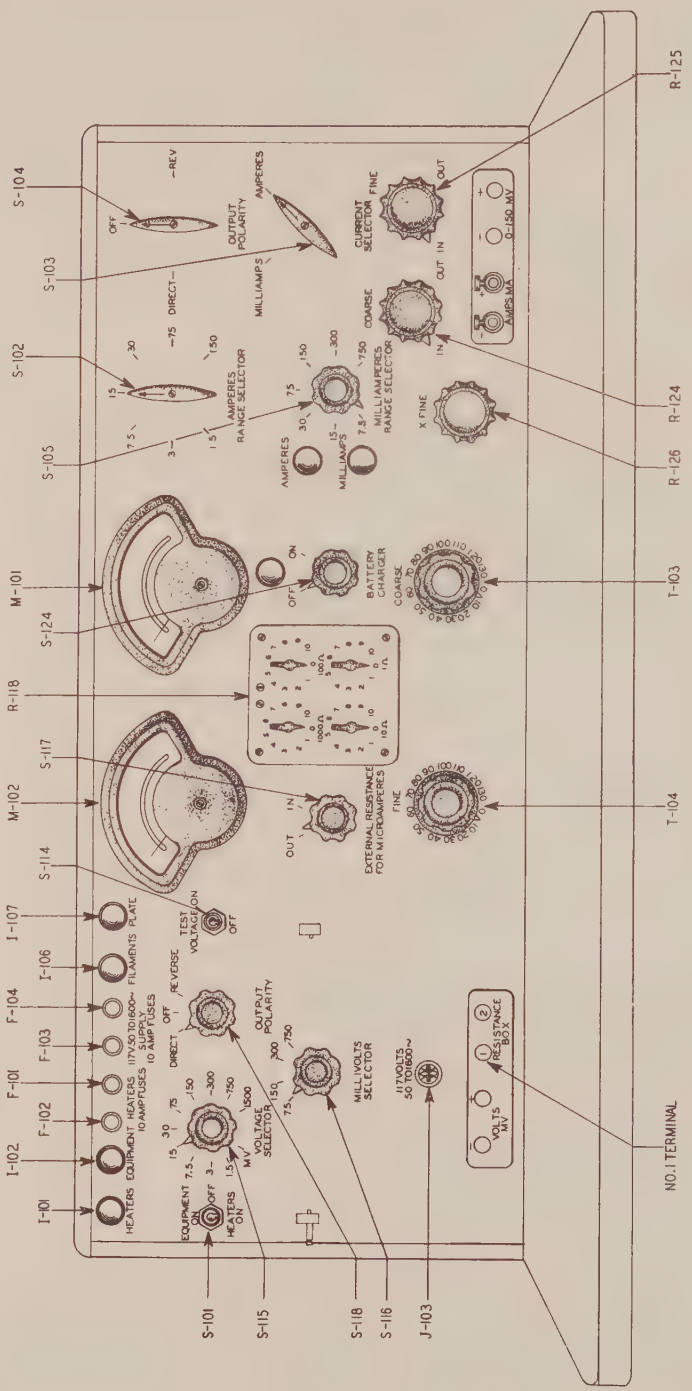


Figure 3-1. Front View of Control Panel of Model 260A DC Standards Equipment

OUT, then turn on the equipment by means of the EQUIPMENT switch S-101 on the left side of the control panel. The EQUIPMENT pilot lamp will go on. Then turn the TEST VOLTAGE switch S-114 to ON. The FILAMENT pilot lamp I-106 goes on immediately and the PLATE pilot lamp I-107 lights after a time delay (the rectifier tube filaments are allowed to warm up before plate voltage can be applied). The voltmeter section is now ready for operation.

b. CALIBRATION. - The following procedure should be adhered to in setting up voltage calibration.

(1) Connect the voltmeter to be tested to VOLTS binding posts, observing polarity.

(2) Turn the VOLTAGE SELECTOR switch S-115 and MILLIVOLTS SELECTOR switch S-116 to a marking equal to, or one step greater than, the full scale voltage of the voltmeter to be tested.

(3) Check to see that both COARSE and FINE controls are at zero, then move the OUTPUT POLARITY switch S-118 to DIRECT (or REVERSE if polarity is to be the opposite from what is marked on the panel). This switch connects the power supply to the voltmeter being calibrated.

(4) Set the FINE variable auto-transformer control T-104 to its mid-position.

(5) Rotate the COARSE variable auto-transformer control T-103 slowly until the desired standard instrument reading is approximated.

(6) Rotate the FINE control to set the standard instrument pointer on the desired value.

(7) Read the deflection on the test voltmeter.

(8) Return the COARSE and FINE controls to zero before disconnecting the voltmeter being calibrated. After all testing has been completed turn off TEST VOLTAGE and EQUIPMENT switches.

3. DC MICROAMMETER CALIBRATION.

a. PRELIMINARY. - Check to see that the OUTPUT POLARITY switch S-118 on the left side of the panel is OFF, then turn on the equipment by means of the EQUIPMENT switch S-101 on the left side of the control panel. The EQUIPMENT pilot lamp will go on. Then turn the TEST VOLTAGE switch S-114 to ON. The FILAMENT pilot lamp goes on immediately, and the PLATE pilot lamp lights after a time delay. (The rectifier tube heaters are allowed to warm up before plate voltage can be applied.)

The approximate resistance of the microammeter to be calibrated must be known for maximum accuracy.

This resistance can be determined by applying enough voltage to the meter to bring it to full scale then, while holding the voltage constant, adding series resistance until the meter reads half scale. The resistance added is equal to the resistance of the meter. Start test with a low voltage. Refer to figure 4-1 and note that RESISTANCE BOX and VOLTS-MV terminals can be connected up to run this test.

b. CALIBRATION. - The following procedure should be adhered to in microammeter calibration.

(1) Place the EXTERNAL RESISTANCE FOR MICROAMPERES to the IN position. This operation places a fixed resistor of 88,890 ohms and a variable resistor R-118 of 11,110 in series with the microammeter.

The purpose of the 11,110 ohm resistor is to permit the operator to reduce the total 100,000 ohms series resistance by whatever resistance is represented by the microammeter under test. Thus maximum accuracy can be obtained.

With a series resistance of 100,000 ohms (including test meter) the voltage given in table 3-1 should be set up to obtain the desired full scale microampere ranges.

TABLE 3-1. VOLTAGES FOR MICROAMPERE RANGES

MICROAMPERES	VOLTAGE
75	7.5
150	15
300	30
750	75
1500	150
3000	300

(2) Connect microammeter to be tested with negative to VOLTS terminal and positive to the No. 1, or left terminal of the RESISTANCE BOX.

(3) Turn the VOLTAGE SELECTOR switch S-115 to the position as determined from table 3-1.

(4) Check to see that both the COARSE and FINE variable auto-transformer controls are at zero, then move the OUTPUT POLARITY switch S-118 on the left side of the panel to DIRECT (or REVERSE if polarity is to be the opposite from what is marked on the panel). This switch connects the power supply to the microammeter being calibrated.

(5) Set the FINE control to its mid-position.

(6) Rotate the COARSE control slowly until the desired standard instrument reading is approximated.

(7) Rotate FINE control to set the standard instrument pointer on desired value.

(8) Read the deflection on the microammeter.

(9) Return the COARSE and FINE controls to zero before disconnecting the microammeter being calibrated. After all testing has been completed turn off the TEST VOLTAGE and EQUIPMENT switches.

4. DC AMMETER CALIBRATION.

a. PRELIMINARY. - Check to see that the OUTPUT POLARITY switch (S-104 on right of panel) is off, then turn on the EQUIPMENT switch S-101 on left side of panel. The COARSE and FINE resistor controls on the right side of the panel must be set to their full counter-clockwise position. The X-FINE control is a carbon pile and must be rotated counter-clockwise until it becomes loose.

b. CALIBRATION. - The following procedure should be adhered to in ammeter calibration.

(1) Connect the ammeter to be tested to the AMPS-MA terminals at the right side of the panel, observing polarity.

(2) Turn CURRENT SELECTOR S-103 to AMPERES or MILLIAMPERES as may be the case for the ammeter under test.

(3) Select the full scale range by means of the AMPERES RANGE SELECTOR S-102 or the MILLIAMPERES RANGE SELECTOR S-105 after setting the CURRENT SELECTOR.

(4) Check to see that the COARSE, FINE and X-FINE resistor controls are counter-clockwise, i.e., in the IN position, then move the OUTPUT POLARITY switch S-104 on the right side of the panel to DIRECT (or REVERSE if the polarity is to be the opposite from that marked on the panel).

(5) For the 30, 75, 150 ampere ranges rotate the X-FINE control R-126 clockwise to set the standard instrument pointer on the desired value. For the 15 ampere range use the COARSE and X-FINE controls. For all ranges below and including 7.5 amperes use all three controls, X-FINE, FINE and COARSE.

(6) Read the deflection of the ammeter promptly. Do not take more charge from the battery than necessary on the high current ranges.

(7) Turn resistor controls counter-clockwise to return the standard instrument to near zero before removing instrument. After all testing has been completed turn off the EQUIPMENT switch.

5. ELECTRODYNAMIC AC WATTMETER CALIBRATION.

Electrodynamic wattmeters are calibrated with DC by applying the procedure for calibration of a voltmeter to the voltage side and the procedure for calibration of an ammeter to the current side simultaneously. First set the rated voltage across the voltage side; then bring the current up from zero. Read and record the indication of

the wattmeter, the current standard and the voltage standard. Induction wattmeters must be calibrated with AC power of the proper frequency.

6. SHUNT 0-150 MILLIVOLT RANGE.

a. PRELIMINARY. - Check to see that the OUTPUT POLARITY switch (S-104 on the right side of panel) is off, then turn on the EQUIPMENT switch (S-101 on left side of the panel). The COARSE resistor control must be rotated full counter-clockwise. X-FINE is a carbon pile, and need only be loosened by turning it to the left.

b. CALIBRATION. - The following procedure should be adhered to in the use of this range.

(1) Connect the millivoltmeter to be tested to the 0-150 MV terminals observing polarity. Connect + and - AMPS-MA terminals together with a heavy lead.

(2) Turn the CURRENT SELECTOR S-103 to AMPERES.

(3) Turn the AMPERES RANGE SELECTOR S-102 to range desired. One millivolt per ampere of standard current appears across the 0-150 MV terminals.

(4) Make sure the COARSE and X-FINE resistor controls are set to the IN position, i.e., counter-clockwise; then move the OUTPUT POLARITY switch S-104 on the right side of the panel to DIRECT.

(5) Rotate the COARSE and X-FINE control clockwise to set the standard instrument pointer on the desired value.

(6) Read the millivoltmeter being calibrated.

(7) Turn the resistor controls counter-clockwise to return the standard instrument to near zero before removing instrument. After all testing has been completed turn off the EQUIPMENT switch.

7. BATTERY CHARGER.

After using the current calibrating section, the battery should be tested with a hydrometer. The charging rate controls R-127, R-128 and R-129, see figure 2-1, are then set at the indicated specific gravity of the corresponding cell and the charger turned on for 16 hours. To turn on the charger move the EQUIPMENT switch S-101 to HEATERS ON and move the BATTERY CHARGER switch S-124 to ON. The BATTERY CHARGER switch must be OFF before operating the current section.

SECTION IV
THEORY OF OPERATION

1. CIRCUITS FOR CALIBRATION OF DC VOLTMETERS AND MICROAMMETERS.

The circuit for the calibration of voltmeters is not connected to the current side. The voltage circuit consists of a variable AC full wave power supply, voltage dividing networks, a standard instrument and output connections.

The **VOLTAGE SELECTOR** switch S-115 selects the power transformer taps, the voltage dividing network, the **HOOD** interlock for voltages above 150 volts and the standard instrument M-102 resistors; the **MILLIVOLT SELECTOR** switch S-116 selects taps on a voltage divider and also changes the sensitivity of M-102. The **OUTPUT POLARITY** switch S-118 energizes the output terminals **VOLTS-MV** and allows for a reversal of output. The **COARSE** and **FINE** variable auto-transformer controls vary the voltage magnitude of the power supply. Figure 4-1 shows a functional diagram of the calibrating circuit.

The variable resistor R-118 can be used externally by positioning the **EXTERNAL RESISTANCE FOR MICROAMPERES** switch S-117 to the **OUT** position with connections made to the terminals marked **RESISTANCE BOX.** In this manner the resistance of a meter can be determined by applying enough voltage to the meter to bring it to full scale, then holding the voltage constant and adding series resistance by means of the **RESISTANCE BOX** until the meter reads half scale. The resistance added is equal to the resistance of the meter. By doubling the resistance of the circuit the current is lowered by one half.

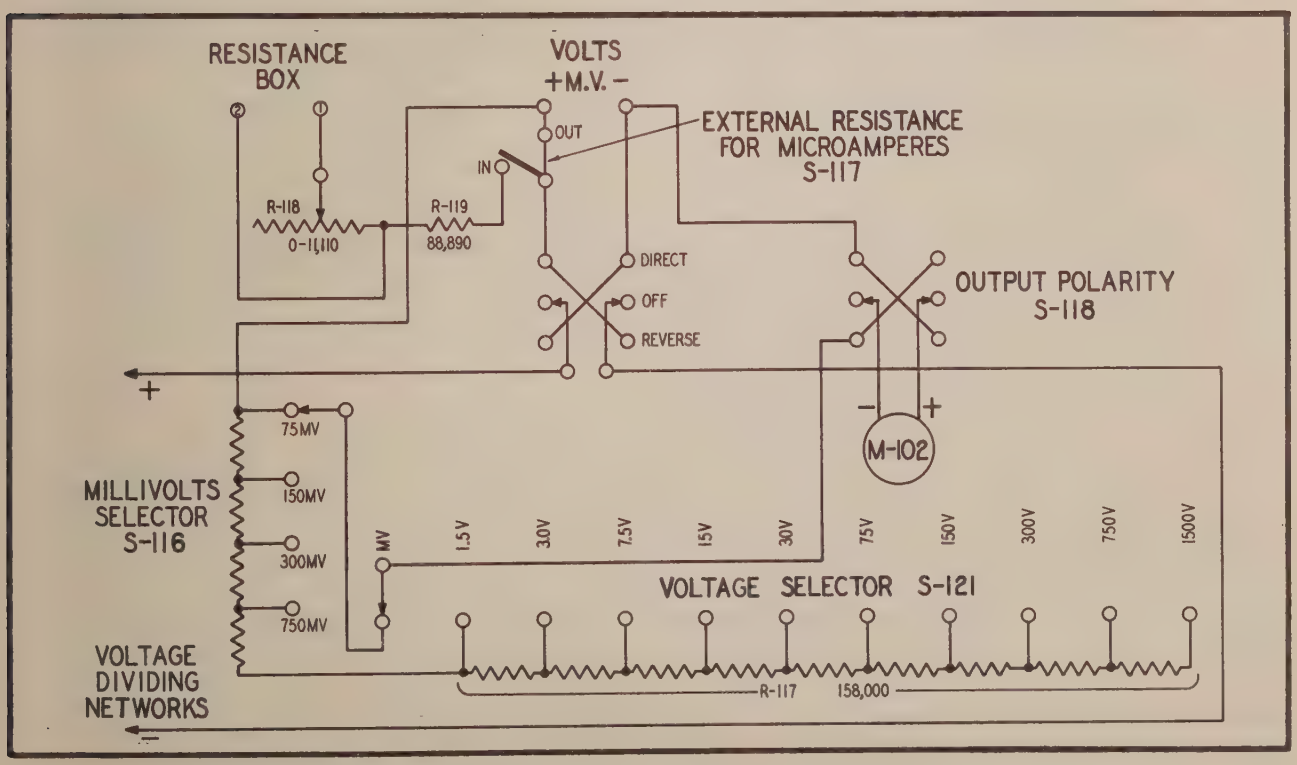


Figure 4-1. Functional Diagram for DC Voltmeter Calibration

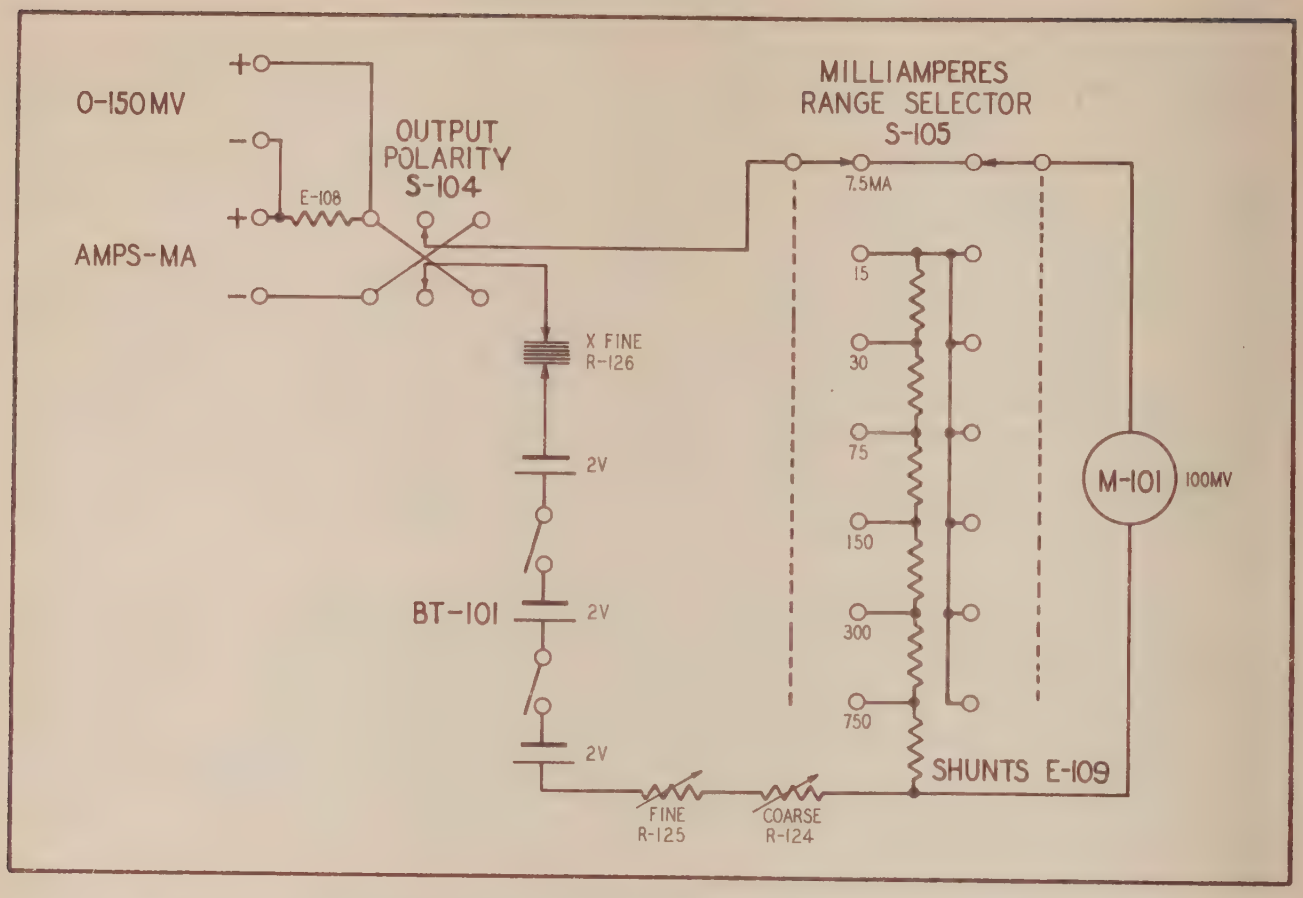


Figure 4-2. Functional Diagram for DC Milliammeter Calibration

Voltmeters are calibrated by applying a standard voltage to the test voltmeter and reading its indication.

Microammeters are calibrated by applying a standard voltage to an accurate series resistor and the microammeter; the total resistance of both being adjusted to 100,000 ohms. The resistance of the microammeter is subtracted from R-118.

2. CIRCUITS FOR CALIBRATION OF DC AMMETERS AND SHUNT 0-150 MILLIVOLT RANGE.

The circuits for the current ranges are divided into two groups. One group covers the range of 7.5 milliamperes to 750 milliamperes. A functional diagram of this circuit is shown in figure 4-2. The second circuit covers the range 1.5 to 150 amperes. The major components are switched and used in both circuits. The functional diagram of the second, or amperes, circuit is shown in figure 4-3. Each circuit is set up with a storage battery source, variable dropping resistors, standard shunts, a standard 100 MV instrument and selector switches. In use, the proper current range is selected and a known current as measured by the standard instrument is passed through the instrument under test.

The CURRENT SELECTOR switch S-103 selects the circuits and magnitude of output for either milliamperes or amperes. The AMPERES RANGE SELECTOR

switch S-102 selects the battery cells, the control resistors R-124, R-125 and R-126 and the standard instrument M-101 shunts for heavy currents. The MILLIAMPERES RANGE SELECTOR switch S-105 selects the battery cells, control resistors R-124, R-125 and R-126 and the standard instrument M-101 shunts for low currents. The OUTPUT POLARITY switch S-104 energizes the AMPS-MA terminals and reverses the output terminals. The X-FINE, FINE and COARSE resistor controls are variable dropping resistors in series with the battery.

A 100 ampere, 100 MV shunt is provided in the equipment and the potential leads brought out to terminals 0-150 MV on the lower right side of the front panel. Millivoltmeters or ammeters less shunts with internal resistances greater than two ohms are connected to these terminals for calibration. The standard current on all ranges is connected through this shunt. Calibrated values for this shunt at no load and at two ohms are listed on a calibration chart furnished with each Model 260A DC Standards Equipment.

3. CALIBRATION OF AC WATTMETERS.

Wattmeters of the electrodynamic type can be calibrated with direct current. The voltage section supplies the standard DC potential, and the current section supplies current. In this procedure, eddy current and frequency errors are assumed to be negligible. If there is doubt as to this, the wattmeter must be compared with one that

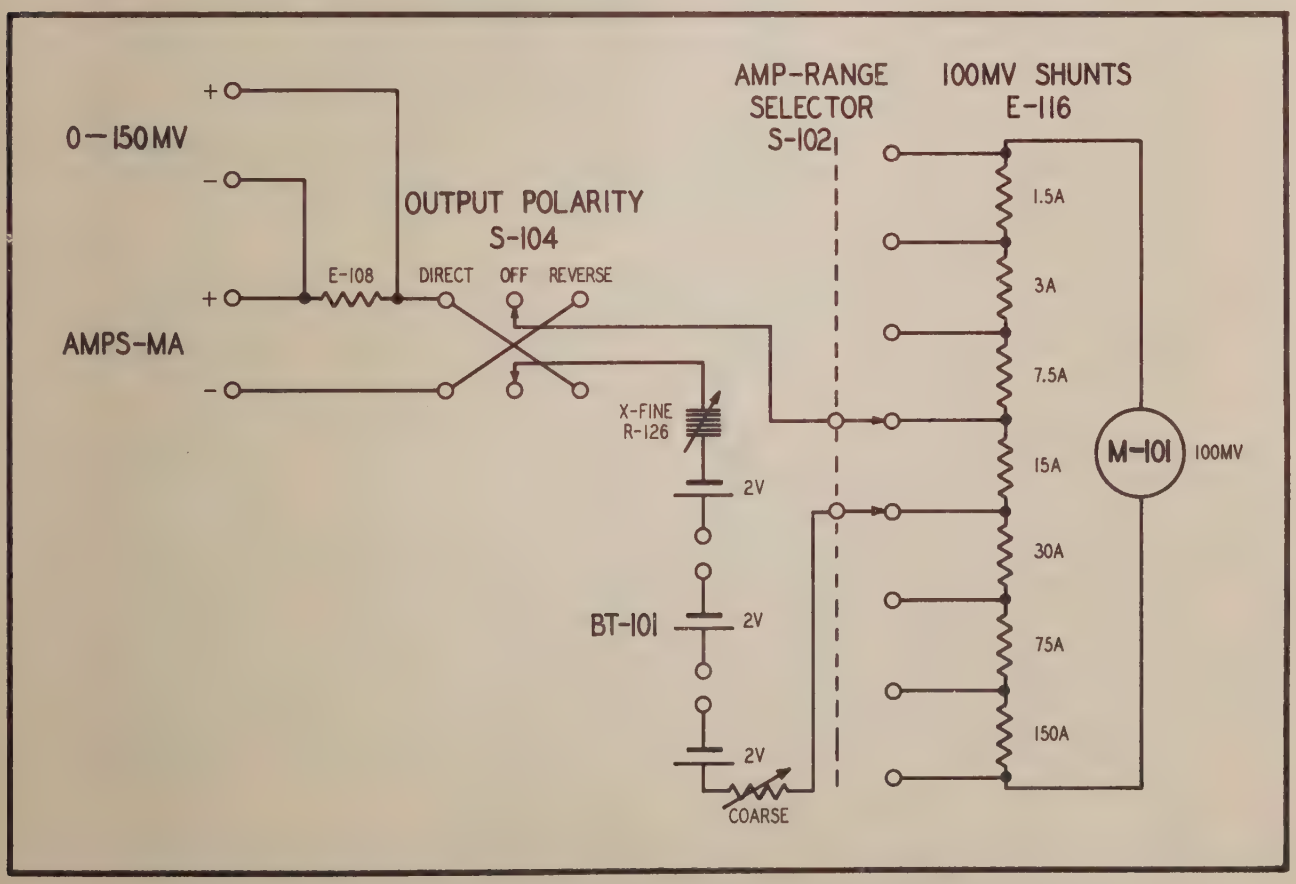


Figure 4-3. Functional Diagram for DC Ammeter Calibration

is known to be free from them, using alternating currents of the proper frequency. In the DC calibration procedure two readings are normally taken at each point with both the current and voltage reversed. The results are averaged to eliminate the effect of the local field.

If the wattmeter has a laminated iron field structure, alternating current of the proper frequency must be used and the instrument compared with an electrodynamic wattmeter which has been calibrated on direct current.

4. SOURCES OF ERROR IN INSTRUMENTS.

a. READING ERRORS. - In general, the construction of the pointer and scale are such that readings can be estimated to one tenth of a scale division. This is possible over most of the scale of moving coil type DC instruments and wattmeters. AC ammeters and voltmeters have crowded scales, and usually only the center portion and right side can be accurately read.

Most precision instruments have mirrors behind the pointers to allow the reader to move his eyes until the reflection is covered by the pointer, thus eliminating parallax.

If minor fluctuations in the readings are observed, the readings should be averaged mentally. Large fluctuations prohibit accurate calibration.

b. ELECTRICAL ERRORS.

(1) SHUNTS. - Care must be taken that shunts are not damaged mechanically. All connections to shunts for test must be firmly bolted with clean contacts. Do not over-tighten the bolts and distort the shunt.

(2) EXTERNAL SHUNT AMMETERS. - External shunt ammeters must be calibrated with the same set of leads connecting the shunt and the millivoltmeter as used with the instrument. When connecting the millivoltmeter to the shunt care must be taken that all contacts are clean and tight. Examine the leads for breaks.

(3) TEMPERATURE. - Electrical instruments are affected by temperature. The temperature is determined by internal heating and the ambient temperature.

The temperature effect is to weaken the springs and cause the instrument to read high by 0.03%/C°. In iron instruments the permeability of the iron decreases about the same amount, compensating for the spring constant change. The magnetic field of most instrument magnets weakens with increase of temperature. The temperature coefficient for copper wire is +0.4%/C° rise. In voltmeters the magnitude of this change is reduced by series resistors of zero temperature coefficient wire. Ammeters without shunts are not temperature sensitive. Ammeters with shunts are usually temperature compensated; if not, the temperature errors can approach the temperature coefficient of copper.

(4) STRAY FIELDS. - Stray fields from connecting wires may cause inaccuracies in the calibration of moving coil ammeters and voltmeters. If stray DC fields are

suspected move the connecting wires. Stray fields will cause a percentage error throughout the scale. DC panel instruments that are intended for use in steel panels must be calibrated in a steel panel. A steel panel distorts the normal field of the internal magnet and changes the readings.

(5) ELECTROSTATIC ATTRACTION. - Electrostatic forces many times exist between the instrument pointer and the glass cover. These surface charges must be dissipated by breathing upon the glass before starting the calibration procedure.

c. MECHANICAL ERRORS.

(1) FRICTION. - Before calibrating an instrument, it should be checked for friction. This is done by energizing the instrument and slowly moving the pointer over the whole scale, stopping at several points. Excessive friction will be evident by a sudden change of reading when the instrument is tapped. Excessive friction may be due to a cracked jewel or other injury due to dropping, buckling of the paper scale, projecting hairs and fibers, dirt or magnetic dust in the air gap.

(2) SPRINGS. - The zero may shift due to the mechanical yielding of the spring. A screw on the face of the instrument is usually provided to correct this.

(3) BALANCE. - The moving system of an instrument should be in good balance. Good balance is checked by bringing the instrument up to half scale reading, then placing it successively on its near side, right side, and left side with no (or a very small) change in reading. Instruments should always be calibrated in the same position as used.

SECTION V
MAINTENANCE

1. GENERAL.

Periodic inspection should be made to see that all screws and bolts are tight. The battery should be checked after use and the charger turned on for overnight charging (16 hours) as discussed in Section III, paragraph 7. Distilled water is added periodically to keep the water level in each cell 1/4-inch above the plates.

If trouble should develop in the precision instruments, shunts and resistors (M-101, M-102, E-109, E-116 and R-117) they should be replaced from stock and no attempt made to repair them. The screws and bolts on the shunts must be tight. Do not over-tighten.

As shown on the schematic wiring diagrams, figures 8-1 and 8-2, the controls and switches are protected with micro switch interlocks. These interlocks may require periodic adjustment. This is accomplished by bending the micro switch arm until 1/32-inch motion of the detent wheel or cam will cause operation of switches.

MAINTENANCE

The type 836 rectifying tubes (V-101, V-102, V-103 and V-104) will give an average of 2000 to 5000 hours of service.

WARNING

THIS EQUIPMENT OPERATES AT DANGEROUS VOLTAGES. Men have been killed by very low voltage circuits. As little as 30 volts may be fatal under the proper combination of circumstances. Haste, heedlessness, attempts to work where there are distracting noises, and attempts to carry on a conversation while servicing lead to personnel and materiel casualties.

2. TROUBLE CHART.

Table 5-1 is a list of troubles and operational difficulties which may be encountered. In the second and third columns are listed the probable causes and recommended remedies. Refer to figures 2-1 and 6-2 to locate components and points. It is recommended that internal trouble shooting be done with an ohmmeter and that internal voltage measurements be made only as a last resort.

TABLE 5-1. TROUBLE CHART

SYMPTOM	CAUSE	REMEDY
VOLTAGE SECTION		
1. No voltage, no current, EQUIPMENT pilot lamp I-102 does not light.	Fuse is blown, F-103 or F-104.	Replace fuse.
	Interlock circuit open.	Close rear door.
	No external power.	Check external power connection; check external fuses.
	Faulty EQUIPMENT switch S-101.	Replace.
	Plug P-101 is disconnected.	Reconnect.
2. No voltage, PLATES pilot lamp I-107 does not light.	Faulty thermal delay relay K-104.	Remove cover and inspect relay contacts. Replace relay.
	24 volt interlock circuit open.	S-115, S-116, S-117 or S-118 is off of detent.

TABLE 5-1. TROUBLE CHART (Continued)

SYMPTOM	CAUSE	REMEDY
		S-115, S-116 or S-118 has been moved with power on. Return COARSE variac control to zero to pick up 24 volt interlock.
		Remove wire to A terminal (4) of TB-102. Continuity should exist between wire and minus 24 volt terminal (2) of TB-102. If continuity does not exist check micro switches S-120, S-121, S-122 and S-123.
	No 24 volt supply (test at TB-102 terminals 1 to 2 1 is positive.)	Test transformer T-101. Check output of rectifier CR-101.
3. FILAMENT pilot lamp I-106 does not light.	Burned out.	Replace.
	Faulty TEST VOLTAGE switch S-114.	Inspect and replace S-114.
4. No voltage output, no standard meter reading.	Faulty VOLTAGE SELECTOR switch S-115.	Inspect switch and check for continuity through switch. Replace switch.
	Faulty transformer T-106.	Measure resistance of windings. Replace if open.
	Faulty filament transformer T-107.	Measure resistance of windings. Replace if open.
	Open filter choke L-101 or L-102.	Replace.
5. No voltage output but correct standard meter reading.	Faulty OUTPUT POLARITY switch S-118.	Check and replace switch.
	Faulty EXTERNAL RESISTANCE FOR MICROAMPERES switch S-117.	Place switch to OUT position and check contacts.

TABLE 5-1. TROUBLE CHART (Continued)

SYMPTOM	CAUSE	REMEDY
6. Low voltage or burden at output.	Faulty tubes V-101, V-102, V-103, V-104.	Replace bad tubes.
	Shorted resistors R-106, R-107, R-108, R-109.	Locate on PANEL BOARD, figure 8-2.
CURRENT SECTION		
1. No current output.	No 24 volt supply.	Test transformer T-101. Check output of rectifier CR-101. TB-102 terminals 1-2.
	Interlock circuit open.	Close rear door.
	Open 24 volt interlock.	Check continuity of interlock circuit. Remove wire to C terminal of K-101 and check continuity of interlocks between wire and minus 24 volt terminal (2) of TB-102.
	Switches S-102, S-103, S-104, S-105, S-124 are off of detent.	Place on position.
	Switches S-102, S-103, S-104, S-105, S-124 have been moved with power on.	Return COARSE control R-124 to IN position
	BATTERY CHARGER switch ON.	Turn battery charger off.
2. Low output.	Battery.	Recharge battery.
3. No 0-150 mv.	No jumper across AMPS-MA terminals.	Place heavy copper jumper across AMPS-MA terminals.

3. POINT-TO-POINT TEST RESISTANCES.

The point-to-point resistances are included to aid in the location of faulty relays, switches, resistors and transformers.

TABLE 5-2. POINT-TO-POINT RESISTANCES

COMPONENT TO BE CHECKED	OHMMETER TEST LEADS ACROSS TERMINALS	RESISTANCE (Ohms)	REMARKS
T-101	1 and 2	2	Remove wire to terminal 1.
T-102	1 and 2	2.5	Remove wire to terminal 1.
T-103	1 and 4	1.5	Remove wires from terminal 1, control at zero.
T-104	2 and 4	1.5	Remove wires from terminal 2, control at zero.
T-105	Black leads	6.5	Remove one lead from terminal board.
T-106	7 and 9	209	Voltage Selector S-115 at MV.
	3 and 6	25	Voltage Selector S-115 at 1500.
	4 and 5	13	Voltage Selector S-115 at 1500.
	1 and 2	1	Remove wire from terminal 1.
T-107	1 and 3	4	Remove wire from terminal 1.
L-101	1 and 2	45	Remove wire from one terminal.
L-102	1 and 2	45	Remove wire from one terminal.
HR-101	1 and 2	50	Remove wire from one terminal.
HR-102	1 and 2	50	Remove wire from one terminal.
R-107, R-108, R-109, R-110	S-115, deck C contact 1 to minus terminal of output Volts MV	145	Output Polarity switch S-118 at Direct.
R-118	Resistance box	0-11,110	External Resistance for Micro-amps switch S-117 to IN position.
K-101 coil	A and B	150	5 amp contacts. Remove wires to terminal A.
K-102 coil	A and B	10	100 amp contacts. Remove wires to terminal A.
K-103 coil	E and F	150	Remove wires from coil terminals.
K-104 coil	Across coil	20	Remove relay cover. Test Voltage switch S-114 in OFF position.
K-105 coil	Across coil	10	Remove wires from one terminal of coil.
K-106 coil	Across coil	10	Remove wires from one terminal of coil.

SECTION VI
SUPPLEMENTARY DATA

1. TECHNICAL SUMMARY.

a. TUBE COMPLEMENT. - This equipment uses four type 836 rectifier tubes in the full wave power supply that feeds the voltage section.

b. BATTERY. - The lead storage battery that supplies calibration current consists of three separate two volt, 168 ampere-hour cells.

c. BATTERY CHARGER. - Consists of a transformer T-101 and selenium rectifier. Output is two volts DC at 20 amperes. The battery can be recharged on a 16 hour recharging cycle.

d. EXTERNAL AC POWER. - The equipment requires 105 to 125 volts, 50 to 1600 cycles and consumes 350 watts. The external source must be stable to ± 2%.

e. CURRENT CALIBRATION RANGES. - Most commercial instruments fall within the ranges given below. The equipment will calibrate within one half of one per cent in these ranges.

TABLE 6-1. DC CURRENT CALIBRATION RANGES

RANGE	MAXIMUM RESISTANCE (Ohms)	BURDEN (Watts)
MICROAMPERES		
75	11,110	
150	11,110	
300	11,110	
750	11,110	
1500	11,110	
3000	11,110	
MILLIAMPERES		
7.5	700	0.04
15	300	0.075
30	160	0.15
75	70	0.4
150	22	0.5
300	16	1.5
750	3.5	2
AMPERES		
1.5	1.78	4
3	0.90	8
7.5	0.27	15
15	0.065	15
30	0.016	15
75	0.006	20
150	0.001	25

f. VOLTAGE CALIBRATION RANGES. - The Model 260A DC Standards Equipment will calibrate to an overall accuracy of one half of one per cent covering the ranges given below.

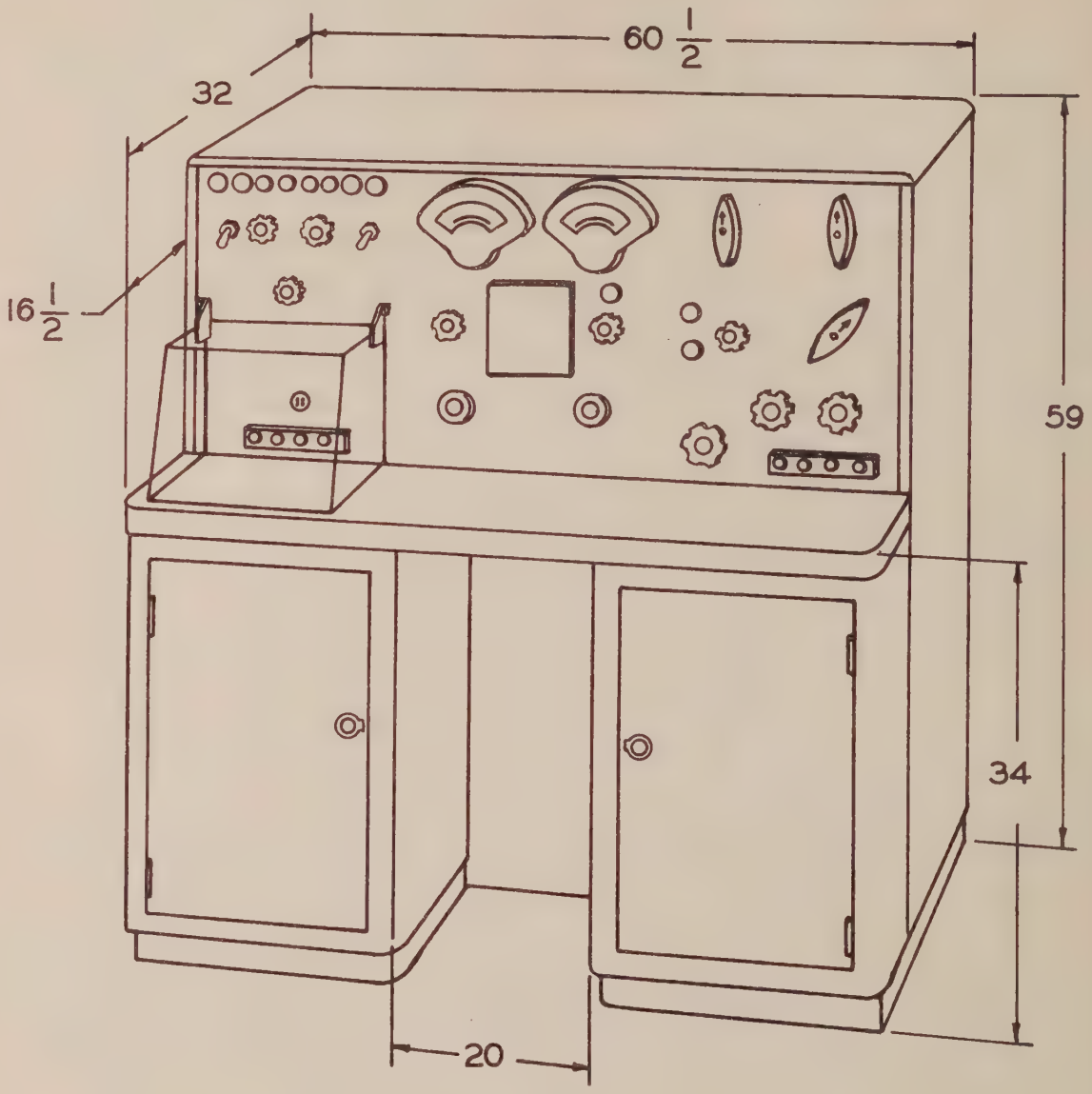
TABLE 6-2. DC VOLTAGE CALIBRATION RANGES

RANGE	MINIMUM RESISTANCE (Ohms)	CURRENT (Amperes)	BURDEN (Watts)
MILLIVOLTS			
75	0.75	0.1	0.0075
150	1.50	0.1	0.015
300	3	0.1	0.030
750	7.5	0.1	0.075
VOLTS			
1.5	15	0.1	0.15
3	30	0.1	0.3
7.5	75	0.1	0.75
15	150	0.1	1.5
30	300	0.1	3
75	750	0.1	7.5
150	1500	0.1	15
300	3600	0.083	25
750	9400	0.080	60
1500	30000	0.050	75

2. INSTALLATION DIAGRAM.

Figure 6-1 shows the outside dimensions of the equipment. The dimensions and weights given in this figure should be checked and compared with doorway dimensions and floor loading of the building in which the equipment is to be installed.

It is recommended that the equipment be moved on the shipping skid to its final location where space permits; therefore, due allowance should be made for the latter's overall dimensions of 42'' wide x 72'' long. The overall height of the equipment when mounted on the skid is 66-1/2''. If it is necessary to move the equipment less skid, a dolly should be used.



ALL DIMENSIONS ARE IN INCHES

Figure 6-1. Outline Dimensions of Model 260A DC Standards Equipment

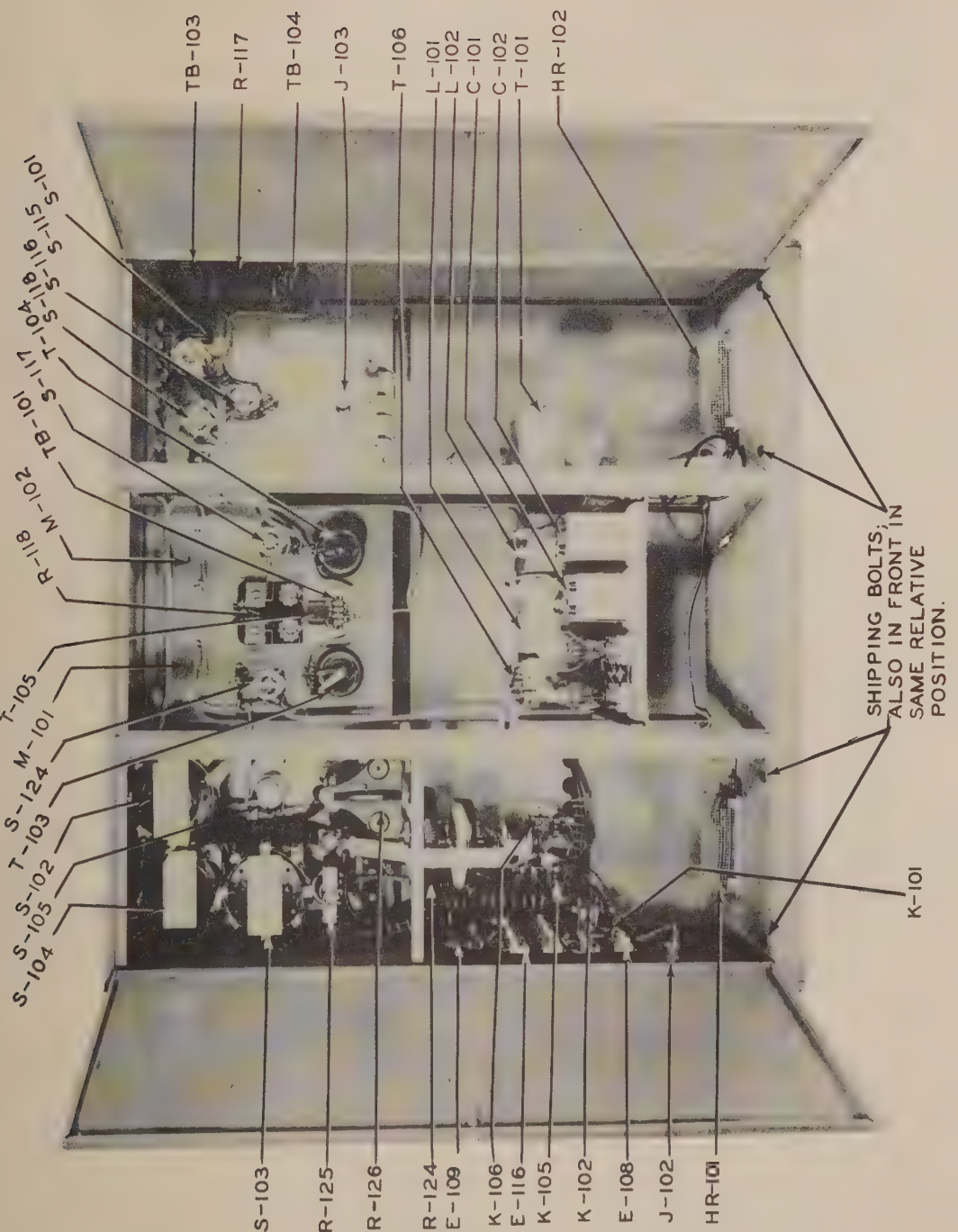


Figure 6-2. Rear View of Model 260A DC Standards Equipment

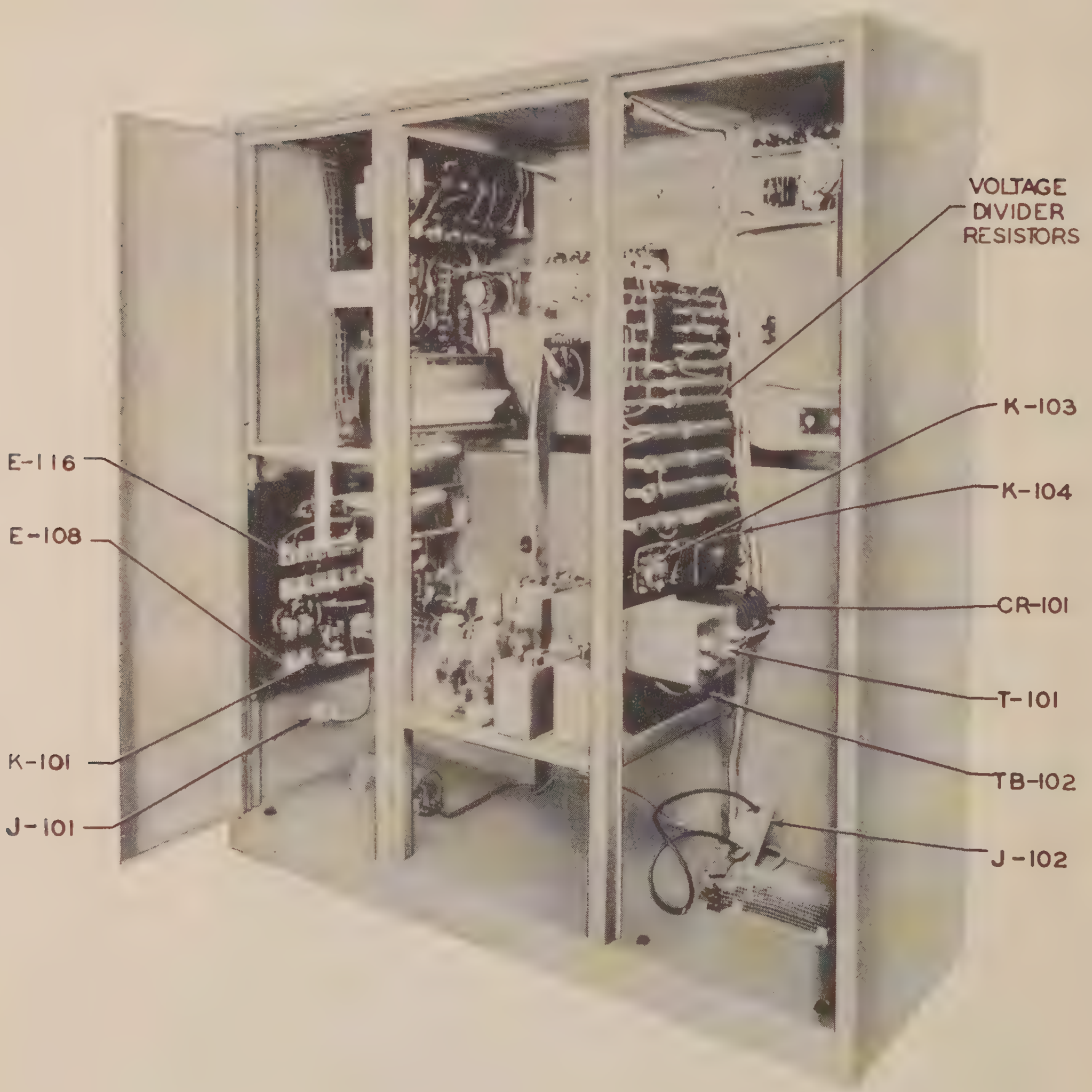


Figure 6-3. Angle View of Rear of Model 260A DC Standards Equipment

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